SCIENCE

NEW SERIES
VOL. LXXIII, No. 1879

FRIDAY, JANUARY 2, 1931

SINGLE COPIES, 15 CTS.
ANNUAL SUBSCRIPTION, $6.00

Entered as second-class matter July 18, 1923, at the Post Office at Lancaster, Pa., under the Act of March 3, 1879.

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VOL. LXXIII — FRIDAY, JANUARY 2, 1931 — No. 1879

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal

Lancaster, Pa. — Garrison, N. Y.

Annual Subscription, $6.00 — Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

PRESENT STATUS OF THEORY AND EXPERIMENT AS TO ATOMIC DISINTEGRATION AND ATOMIC SYNTHESIS[1]

By Dr. ROBERT A. MILLIKAN

CALIFORNIA INSTITUTE OF TECHNOLOGY

MY task to-night is to attempt to trace the history of the development of scientific evidence bearing on the question of the origin and destiny of the physical elements. I shall list ten discoveries or developments all made within the past hundred years which touch in one way or another upon this problem and constitute indications or sign-posts on the road toward an answer. Prior to the middle of the nineteenth century little experimental evidence of any sort had appeared, so that the problem was wholly in the hands of the philosopher and the theologian. Then came, first, the discovery of the equivalence of heat and work and the consequent formulation of the principle of the conservation of energy, probably the most far-reaching physical principle ever developed.

[1] Address of the retiring president of the American Association for the Advancement of Science, Cleveland, December 29, 1930.

Following this and directly dependent upon it came, second, the discovery, or formulation, of the second law of thermodynamics which was first interpreted, and is still interpreted by some, as necessitating the ultimate "heat-death" of the universe and the final extinction of activity of all sorts; for all hot bodies are observed to be radiating away their heat, and this heat, after having been so radiated away into space, apparently can not be reclaimed by man. This is classically and simply stated in the humpty-dumpty rhyme.

As a natural if not a necessary corollary to this was put forward by some, in entire accord with the demands of medieval theology, a *deus ex machinâ* to initially wind up or start off this running-down universe.

Then came, third, the discovery, through studies both in geology and biology, of the facts of evolution

—facts which showed that, so far as the biological field is concerned, the process of creation or upbuilding from lower to higher forms has been continuously going on for millions upon millions of years and is presumably going on now. This tended to call attention away from the *deus ex machinâ,* to identify the creator with his universe, to strengthen the theological doctrine of immanence which represents substantially the philosophic position of Leonardo da Vinci, Galileo, Newton, Francis Bacon, and most of the great minds of history down to Einstein. Neither evolution nor evolutionists have in general been atheistic—Darwin least of all—but their influence has undoubtedly been to raise doubts about the legitimacy of the dogma of the *deus ex machinâ* and of the correlative one of the heat-death. This last dogma rests squarely on the assumption that we infinitesimal mites on a speck of a world know all about how the universe behaves in all its parts, or, more specifically, that the radiation laws which seem to us to hold here can not possibly have any exceptions anywhere, even though that is precisely the sort of sweeping generalization that has led us physicists into error half a dozen times during the past thirty years, and also though we know quite well that conditions prevail outside our planet which we can not here duplicate or even approach. Therefore the heat-death dogma has always been treated with reserve by the most thoughtful of scientists. No more crisp nor more cogent statement of what seems to me to be the correct position of science in this regard has come to my attention than is found in the following recent utterance of Gilbert N. Lewis, namely, "Thermodynamics gives no support to the assumption that the universe is running down." "Gain of entropy always means loss of information and nothing more."

The fourth discovery bearing on our theme was the discovery that the dogma of the immutable elements was definitely wrong. By the year 1900 the element radium had been isolated and the mean lifetime of its atoms found to be about 2,000 years. This meant definitely that the radium atoms that are here now have been formed within about that time, and a year or two later the element helium was definitely observed to be here and now growing out of radium. This raised insistently the question as to whether the creation or at least the formation of all the elements out of something else may not be a continuous process—stupendous change in view-point the discovery of radioactivity brought about, and a wholesome lesson of modesty it taught to the physicist. But a couple of years later, uranium and thorium, the heaviest known elements, were definitely caught in the act of begetting radium and all the allied chain of disintegration products. Since, however, the lifetime of the parent atom, uranium, has now been found to be a billion years or so we have apparently ceased to inquire whence it comes. We are disposed to assume, however, that it is not now being formed on earth. Indeed, we now have good reason to believe that the whole radioactive process is confined to a very few, very heavy elements which are now giving up the energy which was once stored up in them—we know not how—so that radioactivity, though it seemed at first to be pointing away from the heat-death, has not at all, in the end, done so. Indeed, it seems to be merely one mechanism by which stored-up energy is being frittered away into apparently unreclaimable radiant heat—another case of humpty-dumpty.

The fifth significant discovery was the enormous life-time of the earth—partly through radioactivity itself, which assigns at least a billion and a half years—and the still greater lifetimes of the sun and stars—thousands of times longer than the periods through which they could possibly exist as suns if they were simply hot bodies cooling off. This meant that new and heretofore unknown sources of heat energy had to be found to keep the stars pouring out such enormous quantities of radiation for such ages upon ages.

The sixth discovery, and in many ways the most important of all, was the development of evidence for the interconvertibility of mass and energy. This came about in three ways. In 1901 Kaufman showed experimentally that the mass of an electron could be increased by increasing sufficiently its velocity, *i.e.,* energy could be definitely converted into mass. About the same time the pressure of radiation was experimentally established by Nichols and Hull at Dartmouth and Lebedew at Moscow. This meant that radiation possesses the only distinguishing property of mass, the property by which we define it, namely, inertia. The fundamental distinction between radiation and matter thus disappeared. These were direct, experimental discoveries. Next in 1905 Einstein developed the interconvertibility of mass and energy as a necessary consequence of the special theory of relativity. If, then, the mass of the sun could in any way be converted into radiant heat there would be an abundant source of energy to keep the sun going as long as necessary, and all our difficulties about the lifetimes of the sun and stars would have disappeared. But what could be the mechanism of this transformation?

Then came the seventh discovery, which constituted a very clear fingerpost, pointing to the possibility of the existence of an integrating or building up process among the physical elements, as well as in biological forms, in the discovery that the elements are all definitely built up out of hydrogen; for they—the ninety-two different atoms—were all found, beginning about

1913 by the new method of so-called positive ray analysis, to be exact multiples of the weight of hydrogen within very small limits of uncertainty. This fact alone raises very insistently the query as to whether they are not being built up somewhere out of hydrogen now. They certainly were once so put together, and some of them, the radioactive ones, are now actually caught in the act of splitting up. Isn't it highly probable, so would say any observer, that the inverse process is going on somewhere, especially since the process would involve no violation either of the energy principle, or of the second law of thermodynamics; for hydrogen, the element out of which they all must be built, has not a weight exactly one in terms of the other ninety-two, but about one per cent. more than one, so that since mass or weight had been found in the sixth discovery to be expressible in terms of energy, the union of any number of hydrogen atoms into any heavier element meant that one per cent. of the total available potential energy had disappeared and was therefore available for appearance as heat. When, about 1914 or 1915, this fact was fitted by MacMillan, Harkins, and others into the demand made above in the fifth discovery for a new source of energy to keep the sun pouring out heat so copiously for such great lengths of time, it seemed to the whole world of physics that the building up of the heavier elements out of hydrogen under the conditions existing within the sun and stars had been pretty definitely proved to be taking place. This would not provide an escape from the heat-death, but it would enormously postpone it, *i.e.*, until all the hydrogen in the universe had been converted over into the heavier elements.

But by this process the suns could stoke at most but one per cent. of their total mass, assuming they were wholly hydrogen to begin with, into their furnaces, and 99 per cent. of the mass of the universe would remain as cold, dead ash when the fires were all gone out and the heat-death had come. But about 1917 the astronomer began to chafe under the time-limitation thus imposed upon him, and this introduced the eighth consideration bearing upon our theme. He could get a hundred times more time—from now on much more than that because only a small fraction of the matter in the universe is presumably now hydrogen—by assuming that, in the interior of heavy atoms, occasionally a negative electron gets tired of life at the pace it has to be lived in the electron world, and decides to end it all and commit suicide; but, being paired by nature in electron-fate with a positive, he has to arrange a suicide pact with his mate, and so the two jump into each other's arms in the nucleus and the two complementary electron lives are snuffed out at once; but not without the letting loose of a terrific death-yell, for the total mass of the two must be transformed into a powerful ether pulse which by being absorbed in the surrounding matter is supposed to keep up the mad, hot pace in the interiors of the suns. This discovery, or suggestion to account for the huge estimated stellar lifetimes, of the complete annihilation of positive and negative electrons within the nucleus makes it unnecessary to assume, at least for stellar lifetime purposes, the building up of the heavier elements out of hydrogen. Indeed, it seems rather unlikely that both kinds of processes, atom-building and atom-annihilating, are going on together in the same spot under the same conditions, so we must turn to further experimental facts to get more light.

The ninth signpost came into sight in 1927 when Aston made a most precise series of measurements on the relative masses of the atoms which made it possible to subject to a new test the Einstein formula for the relation between mass and energy, namely, $E = mc^2$. This Aston curve is one of the most illuminating finger-pointings we now have. It shows:

1. That Einstein's equation actually stands the quantitative test for radioactive or disintegrating processes right well, and therefore receives new experimental credentials.

2. That the radioactive or disintegrating process with the emission of an alpha ray must be confined to a very few heavy elements, since these are the only ones so situated on the curve that mass can disappear, and hence heat energy appear through such disintegration.

3. That all the most common elements except hydrogen are already in their most stable condition, *i.e.*, their condition of minimum mass so that if we disintegrate them we shall have to do work upon them, rather than get energy out of them.

4. That therefore man's only possible source of energy other than the sun is the upbuilding of the common elements out of hydrogen or helium or else the entire annihilation of positive and negative electrons, and there is no likelihood that either of these processes is a possibility on earth.

5. That if the foregoing upbuilding process is going on anywhere, the least penetrating and the most abundant radiation produced by it, that corresponding to the formation of helium out of hydrogen, ought to be about ten times as energetic as the hardest gamma rays, *i.e.*, it ought to correspond to about twenty-six million electron-volts in place of two and a half million.

6. That other radiations corresponding to the only other abundant elements, namely, oxygen (O, N, C), silicon (Mg, Al, Si), and iron (iron group), should be found about 4 times, 7 times and 14 times as energetic as the "helium rays."

7. That the radiation corresponding to the smallest annihilation process that can take place—the suicide of a positive and negative electron—is 350 times as energetic as the hardest gamma ray, or 35 times as energetic as the "helium ray."

This brings me to the tenth discovery, that of the cosmic rays. These reveal:[2]

1. A radiation the chief component of which, according to our direct comparison, is five times as penetrating as the hardest gamma ray which, with the best theoretical formula we have relating to energy and penetrating power (the Klein-Nishina), means a ray 10 times as energetic as the hardest gamma ray, precisely as per prediction.

2. Spectral bands of cosmic-radiation that are roughly where they should be to be due to the formation of the foregoing abundant elements out of hydrogen, though for reasons to be given presently, no precise quantitative check is to be expected except in the case of helium.

3. No radiation of significant amount anywhere near where it is to be expected from the annihilation hypothesis, thus indicating that at least 95 per cent. of the observed cosmic rays are due to some other less energetic processes.

4. A radiation that is completely independent of the sun, the great hot mass just off our bows, and not appreciably dependent on the Milky Way or the nearest spiral nebula, Andromeda—one that comes in to us practically uniformly from all portions of the celestial dome, and is so invariable with both time and latitude at a given elevation that the observed small fluctuations at a given station reflect with much fidelity merely the changes in the thickness of the absorbing air blanket through which the rays have had to pass to get to the observer.

This last property is the most amazing and the most significant property exhibited by the cosmic rays, and before the drawing of final conclusions its significance will be discussed. For it means that at the time these rays enter the earth's atmosphere, they are practically pure ether waves or photons. If they were high speed electrons or even had been appreciably transformed by Compton encounters in passing through matter into such high speed electrons or beta rays, these electrons would of necessity spiral about the lines of force of the earth's magnetic field and thus enter the earth more abundantly near the earth's magnetic poles than in lower latitudes. This is precisely what the experiments made during the last summer at Churchill, Manitoba (lat. 59), within 730 miles of the north magnetic pole, showed to be not true, the mean intensity of the rays there being not measurably different from that at Pasadena in latitude 34.

Nor is the conclusion that the cosmic rays enter the earth's atmosphere as a practically pure photon beam dependent alone upon these measurements of last summer. It follows also from the high altitude sounding balloon experiments of Millikan and Bowen in April, 1922, taken in connection with the lower balloon flights of Hess and Kolhörster in 1911–14. For in going to an altitude of 15.5 kilometers we got but one fourth the total discharge of our electroscope which we computed we should have obtained from the extrapolation of our predecessors' curves. This shows that somewhere in the atmosphere below a height of 15.5 kilometers the intensity of the ionization within a closed vessel exposed to the rays goes through a maximum and then decreases, quite rapidly, too, in going to greater heights. We have just taken very accurate observations up to the elevation of the top of Pike's Peak (4.3 kilometers) and found that within this range the rate of increase with altitude is quite as large as that found in the Hess and Kolhörster balloon flights, so that there can be no uncertainty at all about the existence of this maximum. Such a maximum, however, means that the rays, before entering the atmosphere, have not passed through enough matter to begin to get into equilibrium with their secondaries—beta rays and photons of reduced frequency—in other words, that *they have not come through an appreciable amount of matter in getting from their place of origin to the earth.*

This checks with the lack of effect of the earth's magnetic field on the intensity of the rays and the two phenomena, of quite unrelated kinds and brought to light years apart, when taken together, prove most conclusively, I think, that the cosmic rays can not originate even in the outer atmospheres of the stars, though these are full of hydrogen and helium in a high temperature state, but that they must originate rather in those portions of the universe from which they can come to the earth without traversing matter in quantity that is appreciable even as compared with the thickness of the earth's atmosphere—in other words, *that they must originate in the intensely cold regions in the depths of interstellar space.*

Further, the more penetrating the beta rays produced by Compton encounters the greater the thickness of matter that must be traversed before the beam of pure photons which enters the atmosphere gets into equilibrium with its secondaries, and until such equilibrium is reached, the apparent absorption coefficient must be less than the coefficient computed with the aid of the Klein-Nishina formula from the energy released in the process from which the radiation arises.

[2] See articles by Millikan and Millikan and Cameron, *Phys. Rev.*, December 1, 1930, and February or March, 1931.

Now the Bothe-Kolhörster experiments of about a year ago show that when the energies of the incident photons are sufficiently high the beta rays released by Compton encounters do indeed become abnormally penetrating so that it is to be expected that, for the cosmic rays produced by the formation of the heavier of the common elements like silicon and iron out of hydrogen, the observed absorption coefficients will be somewhat smaller than those computed from the energy available for their formation. This is precisely the behavior which our cosmic ray depth-ionization curve actually reveals. At the highest altitudes at which we have recently observed (14,000 feet) the helium rays have reached equilibrium with their secondaries, and the observed and computed coefficients agree as they should. For the oxygen rays the observed coefficient is a little lower than the computed value—about 17 per cent. lower—for the silicon rays still lower—about 30 per cent.—and for the iron rays considerably lower still—about 60 per cent.—all in beautiful qualitative agreement with the theoretical demands as outlined.

The foregoing results seem to point with much definiteness to the following conclusions:

1. That the cosmic rays have their origin, not in the stars, but rather in interstellar space.

2. That they are due to the building in the depths of space of the commoner heavy elements out of hydrogen which the spectroscopy of the heavens shows to be widely distributed through space. That helium and the common elements oxygen, nitrogen, carbon and even sulphur are also found between the stars is proved by Bowen's beautiful recent discovery that the "nebulium lines" arise from these very elements.

3. That these atom-building processes can not take place under the conditions of temperature and pressure existing in the sun and stars, the heats of these bodies having to be maintained presumably by the atom-annihilating process postulated by Jeans and Eddington as taking place there.

4. All this says nothing at all about the second law of thermodynamics or the "Wärme-Tod," but it does contain a bare suggestion that if atom formation out of hydrogen is taking place all through space as it seems to be doing, it may be that the hydrogen is somehow being replenished there too from the only form of energy that we know to be all the time leaking out from the stars to interstellar space, namely, radiant energy. This has been speculatively suggested many times before in order to allow the creator to be continually on his job. Here is perhaps a little bit of *experimental* finger-pointing in that direction. But it is not at all proved nor even perhaps necessarily suggested. If Sir James Jeans prefers to hold one view and I another on this question no one can say us nay. The one thing of which you may all be quite sure is that neither of us *knows* anything about it. But for the continuous building up of the common elements out of hydrogen in the depths of interstellar space the cosmic rays furnish excellent experimental evidence. I am not unaware of the difficulties of finding an altogether satisfactory kinetic picture of how these events take place, but acceptable and demonstrable facts do not, in this twentieth century, seem to be disposed to wait on suitable mechanical pictures. Indeed, has not modern physics thrown the purely mechanistic view of the universe root and branch out of its house?

SCIENTIFIC EVENTS

ANNUAL REPORT OF THE DIRECTOR OF THE U. S. GEOLOGICAL SURVEY

THE annual report recently issued by Dr. George Otis Smith, director of the U. S. Geological Survey, states that the fifty-first year of the U. S. Geological Survey has been the largest and broadest of its history in expenditure and in activities. The sum of more than four million dollars was expended in highly specialized service, yielding results much varied in type but alike in contributing to the industrial development of the country.

The Geological Survey has been most intimately connected with western development, and that development is far from completed. The strictly exploratory work of the survey is now in large measure confined to Alaska, but the more intensive phases of agricultural, industrial and mining development have barely begun in much of the western territory.

Some measure of the increasing activity of the survey is afforded in the statistical record of its fifty-first year. As compared with the previous year, the fiscal year 1930 shows increases of nearly 10 per cent. in total expenditures, nearly 20 per cent. in new maps issued, and nearly 30 per cent. in number of book publications. The personnel, of which more than 80 per cent. is professional in type, was larger than even in the years when the Bureau of Mines was a branch of the organization. Indeed, the appropriations this year exceeded by 50 per cent. those for 1910, the last year before the Bureau of Mines was separated from the Geological Survey, and the total expenditures in 1930, including cooperative funds, were more than

double those in 1910. This 20-year period since the separation of these two services especially directed to the promotion of the mining industry has been one of notable growth for both; yet because of the postwar economies their growth has not approached that of the industry they serve.

The discovery of geology by industry in recent years has placed the small corps of government scientists under new and larger obligations. The army of geologists and engineers in commercial work necessarily looks to the federal service for the collection of geologic facts and the working out of new generalizations and principles. High-pressure industrial development throughout the country has involved an increasing demand for raw materials, with a corresponding larger need for basic engineering information. The demand for intensive study of ore possibilities is most active in the same mining states—Colorado and Nevada—where the first mining work of the Geological Survey was done, the production of the epoch-making monographs on Leadville, Eureka and the Comstock, which had as their purpose to meet the anxious desires "of miners as well as of students of geology and economy."

Another phase of governmental activity hardly foreseen in the beginning is the degree to which the public domain is administered on a scientific basis. In the twenty years beginning in 1907 approximately a million dollars was spent for geologic work in areas in which the federal government owns coal lands. Upon this investment of appraising its property the government is now collecting between $400,000 and $500,000 a year in royalties from coal mined from government leases. The oil and gas leases have been still more productive, although the chief contribution of this service to the public interest has been the conservation of the natural resources belonging to the people. The enforcement of the best economic practices by the federal engineers is their contribution to the conservation of life and health, both the zinc and the coal mines under federal supervision showing better accident records than other mines in the same states.

THE NATIONAL PARK SERVICE

THE cooperation of the National Park Service in affording relief to local unemployment during the past season is outlined in detail by Horace M. Albright, director of the National Park Service.

Upon telegraphic receipt last spring from the Washington office of the signing of the 1930 appropriation act of the Interior Department, throughout the national park system action was immediately taken to get construction under way and to purchase equipment. The headquarters office kept in close touch with the field, making adjustments and transfers of funds where necessary to enable the park superintendents to carry on to the best advantage.

In addition to beginning construction and improvement work early in the season, these activities were carried on all summer under full steam and as late into the fall as weather conditions permit. Yosemite National Park, California, reports that it already has continued operations five weeks longer than last year, and proposes to continue until heavy snowfall shuts up the last activities. A few days ago it was reported that despite the heavy snows which necessitated shutdowns of work in the mountainous back country, 358 people were still on the pay roll. This is in addition to the highway construction being carried on under contract.

One of the highway jobs, that of building a tunnel through solid rock, will continue all winter, and the contractor in charge has agreed to take many men from the park forces as other work is suspended through climatic necessity.

In Carlsbad Caverns National Park work will continue all winter on the construction of an elevator shaft, 750 feet deep, and the installation of elevator equipment. Contracts will be awarded within a few days to enable work to commence at once.

At Hot Springs National Park award has just been made covering the construction of a complete hot-water system collecting all hot water from the springs, and also for the construction of concrete reservoirs, pumping station, pipe lines, etc. Much labor will be employed directly by the government.

Contracts will soon be let for the purchase of the pumping and electrical equipment. This project will cost approximately $140,000 and will materially improve the unemployment situation in the Hot Springs region during the period of greatest winter stress.

Work will also be continued during the winter in Wind Cave National Park, where a lighting system will be installed, and in the Mesa Verde, where a deep water well—probably 3,600 feet or more deep—will be drilled.

In Grand Canyon National Park, work will be in progress all winter on the reconstruction of the Bright Angel Trail. This trail is one of the long-remembered features of Grand Canyon by all those who either hike or ride mule-back into the depths of the canyon. It passes along ledges and through clefts in the solid rock walls. The new trail now being constructed will still be just as spectacular as the old one, but of sufficient width and ease of grade to afford perfect safety.

THE NIAGARA FRONTIER RESEARCH COUNCIL

THE Niagara Frontier Research Council has completed its organization to include investigators repre-

senting each branch of pure and applied science in which research is being carried on in the Niagara area. Buffalo and Niagara Falls are the central communities in the area which includes Erie and Niagara Counties of western New York.

The objects of the council are to promote scientific research and coordinate so far as possible the research work done in the area in order that duplication may be prevented and closer relations established between the individuals engaged. Buffalo and Niagara Falls by virtue of their varied industries are said to be particularly fitted to benefit by a council of this sort.

The members and the fields of research they represent include:

Dr. Charles J. Fish, *President*, Buffalo Museum of Science, zoology.
Cedric A. Vincent-Daviss, *Vice-president*, Roessler & Hasslacher, Niagara Falls, N. Y., chemistry.
William N. Kessel, *Secretary*, Buffalo Chamber of Commerce, business.
Christopher H. Bierbaum, Lumen Bearing Company,
Professor John A. Curtin, D'Youville College, meteorol-
engineering.
ogy and astronomy.
George A. Davis, Buffalo, astronomy.
Professor John P. Delaney, Canisius College, seismology.
Robert W. Elmes, Buffalo Chamber of Commerce, business.
Charles Ward Hall, Hall Aluminum Aircraft Corporation, aeronautics.
Dr. L. Grant Rector, University of Buffalo, physics.
Dr. Frances M. Hollingshead, Buffalo Foundation, social science.
Dr. Frans Visser't Hooft, Lucidol Corporation, chemistry.
Dr. Edward W. Koch, University of Buffalo, medicine.
J. Allen Johnson, Buffalo, Niagara and Eastern Power Corporation, engineering.
James A. Johnson, Buffalo, radio.
Stephen T. Lockwood, Buffalo, engineering.
Dr. R. H. Pegrum, University of Buffalo, geology.
R. R. Ridgway, Niagara Falls, electrochemistry.
Wilbert H. Spencer, University of Buffalo, botany.
Dr. A. A. Thibaudeau, State Institute for the Study of Malignant Diseases, physiology.

APPROPRIATIONS FOR GRANTS-IN-AID BY THE NATIONAL RESEARCH COUNCIL

AT its meeting in December the National Research Council's committee on grants-in-aid made eighteen grants for the support of research, as follows:

R. C. Gibbs, professor of physics, Cornell University, the measurement and interpretation of the structure of lines in the atomic spectra of nitrogen; George R. Harrison, professor of physics, Massachusetts Institute of Technology, the determination of transition probabilities in multiple ionized atoms; Mark H. Liddell, professor of English, Purdue University, physical characteristics of speech sounds.

John B. Whitehead, professor of electrical engineering, the Johns Hopkins University, studies upon insulating oils.

Warren O. Thompson, assistant professor of geology, University of Colorado, stratification of unconsolidated deposits.

Sydney W. Britton, professor of physiology, University of Virginia Medical School, the isolation and evaluation of the function of the cortico-adrenal hormone; Israel L. Chaikoff, instructor in physiology, University of California Medical School, the relationship of high fat diets to arteriosclerotic changes in depancreatized dogs: E. A. Doisy, professor of biochemistry, St. Louis University School of Medicine, the female sex hormone; James Ewing, professor of pathology, Cornell University Medical College, the possible tuberculous nature of Hodgkin's granuloma; E. B. Krumbhaar, professor of pathology, University of Pennsylvania School of Medicine, the mechanism of opsonin and bacteriotropin action; Mildred Trotter, associate professor of anatomy, Washington University, the weight of hair in relation to its form, size and color.

Bennet M. Allen, professor of zoology, University of California at Los Angeles, the influence of the thyroid gland and hypophysis upon growth and development; Lee R. Dice, assistant professor of zoology, University of Michigan, variability in subspecies of *Peromyscus maniculatus;* Francis W. Pennell, curator of plants, Academy of Natural Sciences of Philadelphia, Scrophulariaceae of the northwestern part of the United States; Charles H. Philpott, professor of zoology, Harris Teachers College, the effects of snake venoms on certain protozoa.

Melville J. Herskovits, assistant professor of anthropology, Northwestern University, Africanisms in the American Negro; Melville Jacobs, instructor in anthropology, University of Washington, the preservation of extinct or nearly extinct Indian tribal songs of northwestern Oregon.

VERNON KELLOGG,
Permanent Secretary, National Research Council

OFFICERS OF THE AMERICAN CHEMICAL SOCIETY

PROFESSOR MOSES GOMBERG, of the University of Michigan, became president of the American Chemical Society on January 1. Professor Gomberg will serve during 1931, succeeding Dean William McPherson, of the Ohio State University.

Dr. L. V. Redman, vice-president and director of research of the Bakelite Corporation, Bloomfield, New Jersey, has been elected president of the society in 1932. The other nominees were Professor Joel H. Hildebrand, of the University of California; Professor Samuel C. Lind, of the University of Minne-

sota, and Professor Hugh S. Taylor, of Princeton University.

In accordance with a recent change in its constitution, the society now elects each year a president and a president-elect, who serve in successive years. The society's membership of 18,000 in all parts of the country participate in the annual election.

Dr. W. D. Bigelow, director of research of the National Canners Association, Washington, D. C., and Walter A. Schmidt, president of the Western Precipitation Company, Los Angeles, were elected district directors: *Directors-at-large* were named as follows: Thomas Midgley, Worthington, Ohio, noted for his discovery in the laboratories of the General Motors Corporation at Dayton of ethyl gasoline and of a new non-toxic and non-inflammable refrigerant; George P. Adamson, of Searsport, Maine, long identified with chemical industries, including the Baker and Adamson Company, the General Chemical Company and the Allied Chemical and Dye Corporation; Milton C. Whitaker, New York, president of the Catalytic Process Corporation, formerly professor in Columbia University and vice-president of the U. S. Industrial Alcohol Company; R. E. Wilson, Chicago, assistant to the vice-president and in charge of development and patent department of the Standard Oil Company of Indiana.

Councilors-at-large are: F. C. Frary, director of research, Aluminum Company of America, New Kensington, Pa.; Professor H. N. Holmes, Oberlin College; Dr. E. H. Volwiler, director and chief chemist of the Abbott Laboratories, Chicago; R. E. Wilson.

The reserve fund of the society at the beginning of 1930 was just over $300,000 and its trust funds amounted to nearly $184,000. Through the will of W. H. Nichols, $50,000 will be added to the funds of the society. The expenditures of the year were estimated at $557,560.

SCIENTIFIC NOTES AND NEWS

MR. W. C. MENDENHALL, chief geologist of the U. S. Geological Survey, has been made acting director of the survey to succeed Dr. George Otis Smith, who was recently appointed chairman of the reorganized Federal Power Commission.

PROFESSOR ALBERT EINSTEIN has accepted an invitation to become Cecil Rhodes Memorial Lecturer at the University of Oxford, where he will reside during the summer term.

DR. WILLIAM H. WELCH, of the Johns Hopkins University, and Dr. John A. Hartwell, of Cornell University Medical College, were guests of honor at a dinner in New York City on December 6 to celebrate the seventieth anniversary of the German Medical Association of New York.

DR. WALTER B. CANNON, George Higginson professor of physiology at the Harvard Medical School, who recently became a foreign honorary fellow of the Royal Society of Edinburgh, received on November 15 the degree of doctor *honoris causa* from the University of Liége. On November 22 the same honorary degree was conferred on him by the University of Strasbourg.

DR. FREDERICK E. BREITHUT, president of the American Institute of Chemists, Inc., has been elected, *ex officio*, an honorary member of the Chemical, Metallurgical and Mining Societies of South Africa.

THE gold medal of the Radiological Society of North America has been awarded, for achievement in the science of radiology in its application to diseases of women, to Dr. Henry Schmitz, professor of gynecology and head of the department at the Loyola University School of Medicine, Chicago.

THE Mackenzie Davidson Medal of the British Institute of Radiology was awarded to Professor G. P. Thomson, of the Imperial College of Science and Technology, and the Silvanus Thompson Medal to Dr. A. E. Barclay, lecturer in medical radiology and electrology in the University of Cambridge, on the occasion of the recent annual congress and exhibition of the institute. Dr. Thomson and Dr. Barclay delivered memorial lectures.

THE Gedge Prize of the University of Cambridge for original observations in physiology has been awarded to Mr. H. Barcroft, B.A., of King's College, who gained first class honors in the Natural Sciences Tripos, Part II, in 1927.

LORD EUSTACE PERCY was elected president of the Royal Institution, London, on December 1, in succession to the late Duke of Northumberland. Lord Eustace was president of the Board of Education in 1924–29 and this year is president of Section L (Educational Science) of the British Association.

M. LE GÉNÉRAL BOURGEOIS has been elected vice-president of the Paris Academy of Sciences for the year 1931.

HONORARY doctorates have been conferred by the University of Liége on M. Emile Picard, permanent secretary of the Paris Academy of Sciences, on M. Jean Perrin, professor of physical chemistry, and M. Louis Lapicque, professor of physiology, of the Col-

lège de France, and on Dr. A. Calmette, of the Pasteur Institute, Paris.

DR. FRIEDRICH STOTZ, of Heilbronn, the inventor of synthetic adrenaline, who recently celebrated his seventieth birthday, has been named doctor *honoris causa* by the medical faculty of the University of Marburg.

THE General Board of the University of Cambridge has recommended that a professorship of geography be created as from January 1, 1931, and that the present reader in geography, Mr. F. Debenham, be the first holder of the chair. A professorship of experimental psychology will also be created, the present reader in experimental psychology, Mr. F. C. Bartlett, to be the first incumbent. The stipend attached to these professorships is £1,200.

THE chair of zoology in the University of Capetown, vacated by Mr. L. Hogben on his appointment as professor of social biology in the University of London, has been filled by the election of Dr. T. A. Stephenson. Dr. Stephenson has been for some years a lecturer in the department of zoology at University College, London, and was a member of the recent research expedition to the Great Barrier Reef.

DR. WILHELM SCHMIDT has been appointed to succeed the late Professor F. M. Exner as professor of geophysics at the University of Vienna and director of the Institute of Meteorology and Geodynamics.

DR. CARLETON R. BALL, until recently principal agronomist in charge of the office of cereal crops and diseases of the Bureau of Plant Industry of the U. S. Department of Agriculture, has been appointed research associate in the University of California, effective on January 1. He will take up a survey of the relationships of the federal, state and local county or city governments in the numerous and varied agricultural activities in California. This survey will be conducted by the Bureau of Public Administration of the Department of Political Science, with funds provided by the Rockefeller Foundation. It is one, and the first, of a series designed to cover these relationships in all human activities in the state.

DR. NEIL E. STEVENS, of the U. S. Department of Agriculture, has been transferred from the office of horticultural crops and diseases to the office of mycology and disease survey of the Bureau of Plant Industry. In his new assignment Dr. Stevens will conduct research on epidemiology of plant diseases, and will also direct the plant disease survey, formerly under the supervision of Dr. R. J. Haskell. The survey, in cooperation with the state agricultural college experiment stations, extension services and other agencies, will continue to collect, summarize and interpret data on the occurrence and distribution of plant diseases for use by workers in the department and state experiment stations.

VICTOR O. HOMERBERG, associate professor of physical metallurgy at the Massachusetts Institute of Technology, has been appointed technical director of the Nitralloy Corporation, New York City.

MR. P. H. GRIMSHAW has been appointed keeper of the Natural History Department in the Royal Scottish Museum in succession to Dr. J. Ritchie, who was recently appointed Regius professor of natural history in the University of Aberdeen.

PRESIDENT KARL T. COMPTON, of Massachusetts Institute of Technology, addressed the Western Society of Engineers in Chicago on December 1 on "Electron Emission from Metals." He also addressed the alumni of the College of the City of New York at their annual dinner at the Hotel Biltmore on Saturday, November 15, on "What can be Expected of Scientific Research?" On Friday, October 24, he gave the dedication address for the new physical laboratory at the University of Richmond on "Civilization and the Physical Laboratory."

DR. JAMES EWING, professor of pathology at Cornell University Medical College, New York, will give the tenth annual Beaumont lectures on January 26 and 27, in Detroit, under the auspices of the Wayne County Medical Society. The lectures will treat the causation, diagnosis and treatment of cancer.

DR. WALTER B. CANNON addressed the Harvard Medical Society, on December 9, on "The Emotional Increase of Heart Rate."

DR. J. BRONTË GATENBY, of Trinity College, Dublin, lectured at the University of Michigan, under the auspices of the department of zoology, on December 4 and 5, on "X-rays, Radium and Phosphorus, and the Cell," "Review of Various Theories of the Structure of the Cell," "Cytoplasmic Inclusions in the Germ-cell Cycle" and "Lines for Further Research."

PROFESSOR ARTHUR A. ALLEN, of Cornell University, lectured on December 11 and 12 at the University of Michigan under the auspices of the department of zoology on the following subjects: "Courtship and Home Life of Birds," "The Ruffed-Grouse—a Cooperative Investigation" and "The University and the Conservation of Wild Life."

PROFESSOR DOUGLAS JOHNSON, of Columbia University, addressed the Geographic Society of Chicago on December 9 on "The Unresting Sea." The previous day he discussed "Shore Benches of the Pacific Coasts" at a meeting of graduate students and faculty members of the Department of Geology and Geography at Northwestern University, and on December 10 lec-

tured at Wooster College, Ohio, on "Interpretations of Coastal Scenery."

THE International Exhibition of Hygiene at Dresden, which was closed on October 13, will be reopened next year from May 15 to September 30.

Nature reports that an international celebration and exhibition to mark the three hundredth anniversary of the first recognized use of cinchona by Europeans was held at the Wellcome Historical Medical Museum, London, on December 8 and 10. Addresses were given by the Marquis de Merry del Val, Ambassador for Spain; Archbishop Goodier, formerly Archbishop of Bombay; Sir David Prain, formerly director of the Royal Botanic Gardens, Kew, and Sir Humphry Rolleston, Regius professor of physic in the University of Cambridge. There was an extensive collection of exhibits arranged to illustrate the history of cinchona.

WE learn from the *Journal* of the American Medical Association that a microscope thought to be nearly 200 years old has been presented to the New York Academy of Medicine by Dr. Warren Coleman. The case bears a brass plate on which is engraved: "This Microscope brought from Holland by Jan Evertson Keteltas in the year 1649 is given by his Descendant Henry Keteltas Aug 12th 1895 to Doctor Warren Coleman as a pleasant remembrance." According to a plate inside the case, the instrument was made by Benjamin Cole, who is known to have entered business in London in 1751. Authorities believe, therefore, that the microscope given to Dr. Coleman was not the one originally brought to this country in 1649, but one that replaced it about 100 years later.

THE Royal Institution, London, has received an intimation from the Pilgrim Trust that the trustees have allocated the sum of £16,000 to meet the deficiency on the fund for the reconstruction of the institution. The trustees state that, in making this grant, they had regard to the distinguished scientific services rendered to the whole community by the Royal Institution for over a century, and to the approaching Faraday celebrations. They were also not unmindful that the founder of the Royal Institution, Count Rumford, was of American origin.

FOR the purpose of providing adequate laboratory facilities for the departments of medicine, surgery, pathology, bacteriology and allied subjects of the medical curriculum, the Rockefeller Foundation of New York has contributed £100,000 to the University of Sydney. Since the establishment of full-time chairs in medicine, surgery and bacteriology, made possible by the generosity of Mr. George Bosch, of Sydney, the medical school of the university has been brought within the scope of the activities of the Rockefeller Foundation. This gift to the university was the outcome of the visit of Mr. Bosch and Professor Stump to America last January, when they explained in person the plans which the university had in view.

THE committee on pharmacology and therapeutics of the Council on Dental Therapeutics of the American Dental Association announces that it has at its disposal a small fund to aid investigations which may be of therapeutic interest in the field of dentistry. The grants will be limited to the purchase of materials or special equipment. Applications should be addressed to the secretary, Dr. S. M. Gordon, 58 East Washington Street, Chicago, Illinois.

THE *ex-officio* Montana State Board of Entomology, set up in 1913, has devoted itself to the study of Rocky Mountain spotted fever, the tick which carries it and, in recent years, to tick parasites. It now desires to turn over the entire research program, as well as the new laboratory erected by the State of Montana, to the National Institute of Health, created by the Congress in May, 1930. In this plan the Board of Entomology has the support of the American Public Health Association, many state and city health officers and many interested individuals in both the eastern and western United States. The United States Public Health Service has been engaged in the study of this human disease in Montana for many years and has a staff of workers at the board's laboratory at Hamilton, Montana. The Public Health Service has discovered an effective spotted-fever vaccine and has been making it at the Montana laboratory and supplying it to the some thirteen states which need it. The problem of the control of Rocky Mountain spotted fever is much more than a local one and it is believed that it will be more appropriate for the National Institute of Health to have entire charge, thereby relieving the State of Montana, and at the same time making it possible to enlarge the studies and extend them into the other affected states.

AT the anniversary meeting of the Royal Society, Sir Ernest Rutherford, the retiring president, announced that by an alteration of the existing statute regulating the election of fifteen fellows annually, and enacted in 1847, the number to be recommended for election in future would be seventeen.

THE Royal Anthropological Institute, according to *Nature,* has created a class of associates with the object of bringing its facilities for study and research within the reach of the younger workers in anthropological subjects. Associates must be less than twenty-six years of age, they will pay an annual subscription of one guinea only, will receive the institute's monthly publication (*Man*), and will have access to the library and ordinary meetings.

THE East Malling Horticultural Research Station, Kent, England, has arranged for the investigations of six fruit experts from the Dominions to work at the station. The plan is financed by the Empire Marketing Board, and aims at helping fruit production in the Empire by enabling investigators who are taking up fruit research in the Dominions to see at first hand what is being done by their fellow-workers in the home country. Post-graduate workers will be invited to carry out individual research at the station for a period of two years. The East Malling Research Station is the present headquarters of the Imperial Bureau of Fruit Production, one of the eight agricultural research bureaus recently set up to coordinate fruit research throughout the Empire. Mr. R. G. Hatton, director of the station, is at present on an Empire tour, under the auspices of the Empire Marketing Board, during which he will visit Canada, Australia, New Zealand and Ceylon. The research station at East Malling has recently been enlarged as an Empire center for the study of all aspects of fruit culture under temperate conditions. The largest experimental cold store in the world, known as the Ditton Laboratory, has been opened for research into the cold storage of fruit. It contains a "model ship's hold," capable of taking 120 tons of apples, in which conditions on board ship can be almost exactly imitated.

Industrial and Engineering Chemistry reports that the Chung Hua Chemical Research Laboratory was founded in Shanghai in 1929 by the joint effort of the Tienchu Manufacturing Company and P. N. Woo, superintendent and chemical engineer of that concern. The motive for founding this laboratory was to stimulate industrial chemical research and to arouse interest among manufacturers in China to establish industrial fellowships similar to those of the Mellon Institute. At present it has two such fellowships. The laboratory employs three chemists with its annual fund mostly contributed from the founders. The administration is vested in the hands of a board of directors, consisting of nine members, one of whom is the director of the laboratory. Besides cooperating with other parties in solving their chemical and technical problems, the junior staff is doing general analytical work for business people. As a side issue, the laboratory is also acting as purchasing agent for those who wish to buy foreign scientific apparatus and factory equipment. In any case, only a nominal fee is charged and that is utilized solely for the expansion of the laboratory.

DISCUSSION

OUR FAUNA

GATES[1] has recently pointed out how little we know what earthworms may be found in that part of America whose fauna has been studied for the longest period of time, not to mention our lack of knowledge concerning their distribution, life history and ecology.

What is true of earthworms, a group of particular economic importance, is even more true of the moss mites (Oribatoidea). For instance, in one subfamily but one species had been recorded from New York and New England until the writer in 1929 added ten, chiefly from Connecticut. Among the Phthiracaridae but one species had been recorded from New England when in 1930 the same worker added sixteen, of which ten came from one locality. What is true of the above subfamilies, chosen at random, is true of others.

Not only are the species unknown, but in all papers that have come to my attention which claim to analyze or summarize the fauna of a given tract or area the Oribatoidea are ignored, or rarely a generic name appears. Even such "monographs" as Weese's[2] and Blake's,[3] which include turf and soil population, entirely ignore this group. Yet every cubic foot of forest floor contains dozens if not a hundred to two hundred, while no cubic foot of meadowland is without them if present random collections are indicative of general conditions. Furthermore, these animals are visible to a sharp eye.

What is true of the moss mites is equally true of other groups of Acarina, of Tardigrades and of other inconspicuous groups.

Undoubtedly, to know one's fauna is a fundamental necessity and is the only reason for the existence of a national Biological Survey. Were our fauna better known we would not have anatomists, histologists and experimental biologists working on material which represents two or three species (as has been done on Amoeba,[4] Paramecium[5] and even some fishes, or on wrongly identified material as in the case of Hydra,[6] numerous parasites and arthropods).

When one reviews such admirable, comprehensive faunal works as the "Tierwelt Mitteleuropas," "Faune de France," etc., one realizes how far behind is New England, even New York State (not to mention the rest of our extensive domain), in knowing the animal life available for advanced studies. Why should the Biological Survey confine its interest to flowering plants, mammals, birds and a little of other conspicuous forms while all the rest of the plant and

[1] SCIENCE, 60: 266–267, September 13, 1929.
[2] Illinois Biol. Monog., 9: no. 4, 1924.
[3] *Ibid.*, 10: no. 4, 1926.
[4] Schaeffer, Carnegie Inst. Pub. no. 345, p. 3.
[5] Wenrich, *Trans. Am. Micr. Soc.*, 47: 275.
[6] Hyman, *Trans. Am. Micr. Soc.*, 48: 242, ¶ 2.

animal kingdoms are, for the most part, neglected? True, the Bureau of Entomology studies insects but only the few of economic importance. Likewise the National Museum and other museums study some other groups, but what is needed is comprehensive and complete floral and faunal studies similar to those undertaken by the Biological Survey on mammals for all our animals and plants. The work done on mammals is admirable and highly commendable, but why exclude most of the other groups? We have only begun our biological survey.

Again, why do our New England museums and universities spend thousands of dollars to explore remote regions when they have not yet studied the fauna of their own country, not to mention state? There is one definite answer: because their staff is made up largely of mammalogists, ornithologists, herpetologists and other megascopologists who have exhausted the new species of their own countries and must find them elsewhere. The detailed distribution and life history of some of our New England mammals is still to be worked out, but new species from Brazil or the Congo make more appeal to the taxonomist. Could we not have more *bio*logists in our museums, or microfaunologists?

A water-bear enlarged to the size of a polar bear would attract a far bigger sightseeing crowd than would a floe-full of the latter. Why not give our industrial brothers the benefit of our experiences with the microscope and broaden their background to a limitless extent? A beginning has been tried with marked success at the American Museum; why not elsewhere and more extensively? Would not a two-foot model of a specimen of each family of invertebrates raise the hair on the neck of every city dweller? Would anything be more comical and instructive than a row of bee faces enlarged to a diameter of three or six inches? Should not our museums cut down their present large staff of experts on vertebrates in order to take on workers on less conspicuous animals? Would the state and local authorities welcome large models of bizarre invertebrates to take the place of cases of vertebrate skins? Each worker on such models would have to study his local fauna so that the biological survey of the neglected would develop from different centers, but its coordination should center at Washington.

ARTHUR PAUL JACOT
SHANTUNG CHRISTIAN UNIVERSITY,
CHINA

DINOSAUR EGG SHELL FRAGMENTS FROM MONTANA

FOLLOWING the announcement on October 13 that small fragments of shell, probably of dinosaur eggs, were found last summer near Red Lodge, Montana, by the Scott Fund Expedition, of Princeton University, the press has incubated the scraps so assiduously in the desire for "bigger and better" eggs that the resultant newspaper hatch reveals a number of amazing and monstrous hybrids. A foreign publication reports that the eggs found were eight feet long. In America an editorial discloses the delight of collectors in finding a whole nest of complete eggs after a gruelling search, and draws a moral therefrom. Another correspondent intimates that, since the Montana shell scraps are nearly black, the parent dinosaurs were black.

The reappearance of the postulation that dinosaurs had extinction forced upon them by the egg-eating habit of some of the contemporary mammals is one of the examples of atavism among the recent brood of mystic reports.

Due to these and other equally distorted, but popular, tales about the Red Lodge shell bits, several appeals for accurate information have been received. In an attempt to forestall any further exploitation of the discovery, or any even greater exaggeration of its importance, it seems desirable to make a statement concerning the circumstances of the find and the limited material collected.

Mr. E. J. Moles, Jr., a senior in the Princeton department of geology, and the writer spent the latter part of last summer in the vicinity of Red Lodge, at the invitation of Dr. J. C. F. Siegfriedt, in a search for vertebrate fossils which might aid in determining the stratigraphic elements and boundaries of the local Fort Union formation.

An attempt to locate the highly controverted and critical division between the Fort Union and the underlying Lance formation was undertaken in part because of the practical commercial value of the information to local oil and coal operators. This work was an extension of that begun in 1928 and 1929 by Scott Fund expeditions in the Bighorn Basin about twenty miles to the south, near Powell, Wyoming, where the boundary in question was established by the fortunate discovery, in the base of a massive persistent sandstone, of a Puerco, or Lower Fort Union, fauna only twenty feet above dinosaur remains in the Lance shale.

Geological essays sometimes become warm at the mention of the Lance-Fort Union contact because of the many interpretations which various reasoners have given the evidences that the Lance should be regarded as either Upper Mesozoic or Lower Cenozoic in age. The Lance strata east of Red Lodge are poorly exposed in most of the area due to the vegetation and soil mantle, but limited bare rock escarp-

ments in the Dry Creek drainage yielded fragments of dinosaur bones and teeth.

While searching for more dinosaur teeth the collectors found a mammal tooth. This impelled an even more careful examination of the sandstone and shale beds in the immediate vicinity because of the rareness of Lance mammal remains.

Several pieces of egg shell, none over an inch in length, were picked from the surface of the shale close to the tooth and also down the slope below it.

That these fragments were at one time parts of the case about a potential or actual dinosaur embryo is considered probable, though no one has reported a whole egg of this type from America and our evidence is appearance, structure and size as judged from the curvature of the preserved pieces. If they were not flattened by crushing, the whole eggs were very likely larger than the Mongolian eggs, for even the most curved portion of the Montana shell is a segment of a circle greater than the circumference of the complete Mongolian eggs. No thorough comparison has been made with those fragments in the American Museum which are labeled as being from the largest dinosaur eggs discovered in Asia, and are known only from pieces.

In external appearance as well as internal structure, the Montana shell scraps resemble some of the Mongolian dinosaur egg shells and share with them common differences from most egg shells of Chelonians, crocodilians and birds. And, true to anticipation, there are notable differences between some of the Mongolian and the Montana specimens. Deep brown, almost black, the Red Lodge shell pieces are perforated by numerous pores and are characterized externally by hillocks and valleys similar to those on some of the Asiatic dinosaur eggs. In section the mamillar zone appears thin and the pyriform zone thick. Nothing approaching a complete shell or cast of one appeared last summer but more search may reveal material that will permit a further comparison with the Mongolian specimens as well as with the eggs from Rognac, supposedly of the dinosaurian *Hypselosaurus priscus,* and change or fortify the present conclusion about the derivation of the Montana fragments.

The fortuitous association of shell fragments, probably of dinosaur eggs, and of mammalian remains has recalled the old hypothesis that dinosaur eggs were eaten by the Upper Cretaceous mammals to the extent of complete extinction of the giant reptiles. But the evidence is feeble and equivocal, and certainly this particular case of chance proximity is not valid testimony pro or con. Environmental compulsion operating upon an unwieldy group seems a more potent lethal factor for the dinosaurs than does a direct organic aggression. But no one knows with certainty why or how or with what speed they drifted out of the picture. Far from inconceivable is the prospect that dinosaur remains may be found well within the Tertiary (above the Lance) as a result of future prospecting.

The Scott Fund Expedition plans to continue the explorations in the Fort Union and Lance strata during part of next summer, concordant with the general program of geological researches which the Princeton department of geology is sponsoring in the Red Lodge area.

GLENN L. JEPSEN

PRINCETON UNIVERSITY

CONSULTANTS AT THE LIBRARY OF CONGRESS

THE resources of our great national library are well-known, particularly in the fields of law, history and economics, but the extent of its collections in the various branches of science are less generally appreciated.

With a view to facilitating the use of the library by scholars and at the same time giving the staff easier access to the advice of specialists whenever needed, a system of chairs and consultants has recently been established. In outlining the plan to the American Library Association in 1928, Dr. Herbert Putnam explained that the function of the occupant of the chair is neither teaching nor research, but interpretation. As members of university staffs, the business of specialists is to teach or to pursue intensive research of their own. In a word, to concentrate. But as members of a library staff and partaking of its spirit, their business would be to diffuse. A chair implies full-time service with some administrative responsibilities and as yet, no such appointments have been made in science. The consultant, on the other hand, is a member of the library staff on a part-time basis with no administrative responsibility, who cooperates with the staff in matters within his field, and in general, aims to make useful contacts with outside scholars, individually or collectively. Such a group of specialists in the service of the national library is a sort of informal faculty, offering to graduate students, in a measure, what is characteristic in the idea of a national university, mainly, convenient access to the principal collection of books and manuscripts in the United States and indirectly to the other extensive resources of the City of Washington.

Funds have been made available up to the present

time for the appointment of seven consultants, three in literature and history, one each in economics, sociology, philosophy and science. The first consultant in science was Dr. Alfred C. Lane, of Tufts College, in the field of geology. The present consultant is Dr. H. W. Tyler, formerly of the department of mathematics in the Massachusetts Institute of Technology.

No consultant in science will naturally undertake personal responsibility in the field as a whole, but the more modest function of acting as a medium of communication with specialists in the various fields seems within the range of practicability.

The object of this note is to make the plan better known to the readers of SCIENCE with the hope that they may be interested to communicate with the consultant, either in the sense of presenting questions on which information is desired, or offering suggestions for making the service increasingly useful.

H. W. TYLER

REPORTS

THE INTERNATIONAL GEODETIC AND GEOPHYSICAL UNION

THE World War made an unusually wide and enduring breach between scientists belonging to countries arrayed against one another in that conflict. Although geophysics is essentially an international science, strangely enough it has seemed to be precisely in connection with geophysics that the breach was apparently the widest and most enduring. The following translation from the current number of the *Zeitschrift für Geophysik* may be of interest as showing that the breach is now in a fair way to be healed. The London Manifesto, to which reference is made, was a statement drawn up at a meeting that eventually resulted in the organization of the International Research Council. It found its way by implication into the statutes of the Research Council, but all reference to it was removed in 1926.

Extract from the minutes of the general meeting of members of the Deutsche Geophysikalische Gesellschaft held at Potsdam on September 13, 1930, page 503:[1]

Mr. Kohlschütter reported on the negotiations with the International Geodetic and Geophysical Union and on the visit to the meeting of the Union held this year in Stockholm. After a thorough discussion, in which Messrs. Wigand, A. Schmidt, Weickmann, Conrad, Haussmann, Perlewitz and Tams took a chief part, the following resolutions were adopted on motion of Mr. Wigand:

(1) The meeting approves the conduct of the Executive Committee (Vorstand) and of the Stockholm delegates in regard to the International Geodetic and Geophysical Union (unanimously adopted).

(2) The meeting empowers the Executive Committee, in conjunction with the Deutsche Meteorologische Gesellschaft, the Reichsbeirat für das Vermessungswesen, the Conference of Directors of German Hydrological Institutions and the principal German institutions concerned, to prepare the way for the adhesion of Germany to the International Geodetic and Geophysical Union.

In the declaration of adhesion, it shall be stated that adhesion is made on the assumption that the London Manifesto of November 10, 1918, is considered by the Union to be unjustified.

[1] Proceedings of the Deutsche Geophysikalische Gesellschaft, as reported in the *Zeitschrift für Geophysik*. VI. Jahrgang, 1930, Heft 8.

Extract from the annual report of the executive committee of the Deutsche Geophysikalische Gesellschaft for the year 1929–1930 (from October 1, 1929, through September, 1930), page 504:

In April last, the Gesellschaft received through the London Embassy and through the Ministry of Foreign Affairs an invitation from the President of the International Geodetic and Geophysical Union to take part in this year's meeting of the Union at Stockholm. Since Germany is not a member of the International Research Council nor of the Geodetic and Geophysical Union, which is a part of it, German geodesists and geophysicists could participate only as guests. Unfortunately there was attached to this general invitation the condition that the German scientists prepared to take part should address to the President [of the Union] an appropriate request. In our answer, which was decided on at a meeting of the Executive Committee in Berlin on April 28, 1930, we expressed our entire willingness to send to Stockholm several members representing the various branches of geodesy and geophysics, but we felt unable to urge the members in question to make request for an invitation. Although, as we have learned, a number of foreign colleagues urged upon the President [of the Geodetic and Geophysical Union] the desirability of having unconditional invitations sent to the members especially designated by us for the purpose, it was not until the first day of the Stockholm meeting and after being unanimously requested by the delegates present that the President decided to send a telegraphic invitation to the German representatives. This telegraphic invitation, which was warmly seconded by the Swedish local committee, was accepted by Messrs. Angenheister, Hecker, Kohlschütter, Linke and Nippoldt. Though we took part principally in the scientific proceedings, we also took the opportunity to state our views regarding such changes in the organization of the Research Coun-

cil and of the Geodetic and Geophysical Union as we deemed necessary. It is a satisfaction to report that the newly adopted statutes of the Union, and also the statutes of the Research Council, as prepared by the Committee on Revision of Statutes of the Research Council for action at the plenary session of the Council to be held next year, are in substantial conformity with German desires, so that in the opinion of those who took part in the Stockholm meeting the way is now open for German geodesists and geophysicists to join the International Geodetic and Geophysical Union. The adhesion of Germany to the International Research Council is no longer a prerequisite to adhesion to the various unions; the question of adhesion to the International Geodetic and Geophysical Union is, therefore, laid before the members [of the Deutsche Geophysikalische Gesellschaft] for decision.

W. D. L.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

PEN AND INK DRAWINGS FROM PHOTOGRAPHS

THE ordinary method of making line drawings for publication by means of the camera lucida is tedious, especially when minute details are concerned. Photographs are frequently blurred, often do not give enough contrast or are not clear enough to be suitable for publication. The method here presented combines both the clearness of definition of the line drawing and the accuracy of the photograph. Very little seems to be known of the method in scientific fields, but it is used commercially to a considerable extent to make various types of etchings and line sketches.[1] In general, the procedure is to photograph the material, make a print on a good grade of paper and draw over it with India ink. All stippling or other shading may be done directly on the photograph. The print is then placed in solutions which bleach away the photographic image and leave the ink tracing standing out on a white background. If the original photograph is so small that details can not be drawn in easily, it may be enlarged several times, treated as above and the drawing reduced in reproduction.

The process of removing the photographic image is accomplished by two solutions. The first dissolves away the photographic image and the second bleaches the paper.

Solution 1.	Potassium iodide	15 gms
	Iodine	5 "
	Water	500 cc
Solution 2.	"Hypo" crystals	100 gms
	Water	450 cc

When the ink on the drawing is thoroughly dry, quickly immerse the print in solution 1. Rock the tray immediately so that the solution covers the print rapidly and evenly. The photographic image will disappear almost at once, and at the same time the print will become brown from the iodine. As soon as all traces of the photograph have disappeared, remove the print and wash gently in water in order to remove the excess iodine. Then place in solution 2. Here the brown color is completely lost and the print becomes quite white in about five minutes. Transfer to water and wash thoroughly to remove the "hypo." Dry the print by placing it in a horizontal position on blotting paper. It will curl as it drys, but later it can be flattened by dampening the back and placing in a press. Throughout the entire process care should be taken that nothing touches the surface on which the drawing has been made, for the ink smears very easily while wet. The iodine solution may be used repeatedly until it becomes too weak, when it may again be brought to strength by adding more iodine. The "hypo" solution may likewise be used many times.

The method has been used by the writer to make drawings of section of leaves. Microphotographs are taken on a 3¼ x 4¼ inch negative and enlarged to a 5 x 7 inch print. The time required to take the photograph and to complete the entire process is very little more than that required to make a camera lucida drawing. After the chemical treatment no traces of the photograph remain, and the drawing stands out on a white background without any staining or blurring of the print. If desired, pencil or even charcoal may be used in place of the ink.

ERNEST NAYLOR

DEPARTMENT OF BOTANY,
UNIVERSITY OF MISSOURI

[1] J. C. Tobias, "Working up Silver Prints," *Am. Ann. of Photo.*, 44: 30–38, 1930. The writer also wishes to make acknowledgment to J. P. Barham, of the photographic service department of the University of Missouri, who first brought the method to his attention.

A METHOD OF CLEANING MICROSCOPICAL FOSSILS

ONE of the difficulties of cleaning microscopical fossils, already removed from out the matrix, is in keeping them in a desirable position under the microscope, while working on them with a needle. There is always the great danger of crushing them with forceps or of losing them when they jump out of the forceps.

In my work on foraminifera I was able, to a certain

extent, to avoid the dangers referred to through the use of the common adhesive tape. The tape was used in the form of small strips, and the whole manipulation was carried on in the following way. A tiny drop of water was put on the gummed surface of the tape, and the fossil placed on the wet spot in a desirable position. After a few minutes the glue was dried and held the fossil firmly enough to allow of its preparation. When the preparation was finished, the strip of the tape was plunged into water, the fossil removed from the tape with a soft brush and the adherent remains of glue washed off. It is very important to take as little water as possible for fixing fossils on the tape. If the drops were too large, it would not only take too much time before they would dry out sufficiently to give a good hold to fossils, but the latter might sink into the glue which, dried on their surface, would interfere with the work of the needle. The most difficult part of the operation is the fixing of the fossils on the gummed surface in exactly the desired position.

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SPECIAL ARTICLES

AN OBSERVATION WHICH SUGGESTS AN EXPLANATION OF THE ANEMIA IN HOOKWORM DISEASE

DURING the course of an experiment on absorption from the small intestine of the dog in which the mucosal surface of the gut was exposed in a special device for observation of the movements of the villi, the author's attention was attracted by the activity of several hookworms (*Ancylostoma caninum*) attached to the mucosa. While watching one of them through a binocular microscope, a large droplet of blood was seen to emerge suddenly from its anal orifice. Within the next few minutes a considerable number of droplets had been ejected by the same worm. Eight or ten other worms present were all seen to be passing blood in the same manner.

The passing of blood in such quantities naturally aroused our interest, as it seems to suggest a plausible explanation of the anemia in hookworm disease. For, although anemia has long been recognized as the essential feature of the disease, its cause has remained obscure. Hemorrhagic areas, due to the bites of the worms, have been noted, and blood has frequently been found in the digestive tracts of the canine and the human forms of the parasites. Indeed, the worms have been seen to eject blood, both from the mouth and from the anus, on placing them in water after removal from the dead host. But no direct observations on the blood-sucking activities in the living host have been made heretofore, so far as the author is aware. All evidence of the presence of blood in the tracts of the worms has been considered merely as showing that blood may be the principal food of the animals. It has naturally been assumed that, as the worms can not require much blood for food and as the loss to the host by hemorrhage from the mucosa is seldom very great, there must be some other reason for the anemia. Toxins, including agents acting on the blood-forming organs or on the blood cells directly, have been postulated as possible causes. But aside from the finding of a hemolytic agent in extracts from dead worms, the evidence for such toxins has never been convincing. The observations here reported show that, in the case of the dog hookworm at least, blood may be removed from the host to a degree hitherto unsuspected, which indicates that it may be necessary to reconsider the factor of blood-sucking in relation to the causation of anemia.

Although a rather elaborate apparatus was used in the original observations, this is not necessary. The procedure may be successfully carried out as follows. A dog having a fairly heavy infestation, as shown by examination of a fecal smear for ova, is anesthetized by the administration of 0.35 gram of sodium barbital per kilo in approximately 10 per cent. solution, either by mouth or intravenously. In an hour or less the abdomen may be incised in the midline and a loop of bowel pulled out. With sharp scissors the wall of the gut is cut longitudinally on a line opposite the attachment of the mesentery. Hemorrhage from the cut borders of the segment should be checked by the application of spring paper clamps. The activity of the worms may be observed with the unaided eye and with ordinary illumination, but better results can be obtained with a Greenough type binocular microscope of low power and with the field illuminated by means of an arc or other strong source. It is advisable to keep the worms submerged in warm isotonic saline solution to prevent them from drying.

To date, several dogs have been used and some fifty worms examined, all of which were seen to be passing blood as in the first experiment. The frequency of ejection of the droplets varied considerably. In the first two dogs studied, the intervals between ejections varied from 2 seconds to 10 or 15 minutes. However, during several active periods extending over 20 minutes or more, the intervals were never longer than one

minute, the average being for two such extended periods 15 and 22 seconds, respectively. During the periods of rapid ejection the tract of the worm remains more or less distended with blood. One gains the impression that the worm gorges itself with blood before starting to eject. The red material which gradually fills the intestine may be readily seen through the transparent tissues of the worm. The anal end becomes dilated and immediately there occurs a spasmodic contraction, often of sufficient force to move the whole posterior part of the worm. A droplet appears with great suddenness from the anal orifice. It was noticed in the case of some worms that blood may finally cease to replace that ejected and that the worm may gradually become almost white or colorless. When a worm was seen to move to a new point of attachment or when it disengaged itself from a part of the mucosa to which the blood supply had been cut off it was usually white, with little or no blood visible in its tract. Some worms were observed which never became colorless during the entire day. But in these as in the others there were periods when no blood was emitted. In the case of one dog the worms observed were relatively inactive. Periods during which little or no blood was ejected lasted for half an hour or more, and both the frequency and the size of droplets during the active periods tended to be less than in the first experiments. But even in this instance there were occasionally short periods during which large droplets were emitted at intervals of less than a minute.

The color of the blood emitted was sometimes purplish like venous blood, sometimes bright red or arterial in hue. The color seemed to be a characteristic peculiar to the individual worm and hence probably dependent on the local nature of the blood supply at the point of attachment. There was no distinct evidence of any change of color, from red to blue, as the blood passed through the worm. This point may need further study, for one is impressed with the possibility that the enormous amount of blood ingested by the parasite may serve a respiratory function.

The size of the ejected droplet was estimated by collecting a single emission in a capillary pipette containing isotonic salt solution. The blood was mixed and made to a definite volume of 0.5 or 1.0 cc. The red corpuscles were counted in the usual manner. Calculation gives the total number of red cells emitted per drop. In the case of two drops, each from a different worm, there were 1,168,000 and 1,268,000, respectively. Assuming the erythrocyte count of the dog to have been 5,000,000 per cu mm, the droplets would therefore each represent the red cells from approximately 0.25 cu mm of the dog's blood. Knowing the size of the droplet one could easily estimate the daily loss of blood incurred at the expense of the host provided one knew the average rate of ejection by each worm and the number of worms present. Although the normal average rate of ejection is not known at present, one can gain an idea of the possibilities by assuming a rate of, let us say, one ejection per minute per worm, which is certainly not an excessive maximum, as judged by two experiments lasting for over seven hours. On this assumption there will be removed from a dog in this manner 1 cu mm in 4 minutes, 15 cu mm per hour or 360 cu mm per day by a single worm. With 1,000 worms present and similarly active the loss to the host would be 360 cc per day. In this calculation no allowance is made for blood cells digested by the worm, nor, of course, for blood that may be lost by direct hemorrhage at the point of attachment to the mucosa.

Although at present one can only speculate as to the actual amount of blood discharged by the worms under normal conditions, there is every reason to believe that the parasites not only can but do take in and expel much more blood than could be accounted for by their food requirements alone. As to what biological purpose is served by this process, so wasteful of the blood of the host, it is impossible at present to judge.

Although these observations do not tell us anything of the behavior of those forms of the parasite which infest man, they do suggest that the factor of blood-sucking should be reconsidered, on the possibility that this activity of the worms may be found to play a part more important than formerly suspected in the production of anemia in human cases.

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A RELATION BETWEEN ROTENONE, DEGUELIN AND TEPHROSIN

IN a previous communication to this journal[1] it was stated that apparently the principal toxic constituents of derris and cubé roots, namely, rotenone, toxicarol, deguelin and tephrosin, were, from a chemical standpoint, more or less closely related. At the time the report referred to was made, only indirect evidence supporting the assumption was available. This consisted of the similar solubilities of the compounds in many solvents, the identity or close similarity of their empirical formulas, the fact that all contained two methoxyl groups, and, finally, their general behavior toward certain reagents.

As the study of the chemistry of these materials has

[1] E. P. Clark, SCIENCE, 71: 396, April 11, 1930.

progressed, direct evidence of a relationship among three of the compounds has been shown. The essential facts are as follows. Rotenone upon mild oxidation yields dehydrorotenone $C_{23}H_{20}O_6$. This compound when boiled with alcoholic potassium hydroxide and zinc dust gives rise to a hydroxy acid[2] $C_{23}H_{24}O_8$, which, when oxidized with hydrogen peroxide, yields derric acid[3] $C_{12}H_{14}O_7$. Derric acid contains the two methoxyl groups originally present in rotenone and represents one half of the rotenone molecule.

Upon oxidation with potassium ferricyanide deguelin $C_{23}H_{22}O_6$, the light green compound melting at 171° which is found in derris and cubé roots, the leaves of *Cracca vogelii* and the roots of *Cracca toxicara,* gives dehydrodeguelin $C_{23}H_{20}O_6$. This substance, analogous to dehydrorotenone, yields on boiling with alcoholic potassium hydroxide a phenolic monocarboxylic acid $C_{23}H_{24}O_8$, which has been called deguelic acid. Deguelic acid when oxidized with hydrogen peroxide in the same manner as was the acid from dehydrorotenone also yields derric acid.

Tephrosin $C_{23}H_{22}O_7$ when treated with a mixture of sulphuric and acetic acids or with acetic anhydride loses the elements of water and forms dehydrodeguelin. Thus derric acid constitutes one half of the molecule of rotenone, of deguelin and of tephrosin. The evidence also shows that tephrosin is intimately related to deguelin, since the loss of one molecule of water from tephrosin gives dehydrodeguelin. Without further experimental evidence, it appears probable that tephrosin is a hydroxydeguelin. Detailed reports of this work will appear elsewhere.

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DISSOCIATION OF BACTERIUM GRANULOSIS NOGUCHI AND IDENTIFICATION OF THE ORGANISM BY MEANS OF RABBIT IMMUNE SERA

THE viability of *Bacterium granulosis* for periods of a year or more on the semisolid ("leptospira") medium of Noguchi has already been recorded.[1] Recently, on transfer to blood agar of a culture which had stood for 8 months on semisolid medium without transfer, and which had shrunk by evaporation from 8 cc to 2 cc or less, a growth was obtained of discrete, yellowish gray, opaque, dry, bead-like colonies, with rough surface, which were distinct from the semitransparent, grayish, mucoid, confluent colonies usually seen in young cultures of *B. granulosis.* Microscopic examination, however, showed a morphology typical of *B. granulosis.* The strain fermented the usual carbohydrates, and agglutination tests with immune sera prepared in rabbits by means of the ordinary type cultures yielded clearly positive results.

A few smooth mucoid colonies were found among the rough dry ones, and a pure smooth strain was readily isolated from one of these. Plating of rough colonies yielded a growth chiefly of the rough type, with gradual reversion to smooth within 3 or 4 days in those portions of the plate where the colonies were widely separated. Replating every 24 to 48 hours reduced the tendency to reversion until it has practically disappeared. The tendency to the formation of yellow pigment, which is ordinarily seen only in old cultures of *B. granulosis,* is much enhanced in the rough cultures and appears early. The dissociation has since been found in other strains of *B. granulosis,* the identity of which had been uncertain until they were found to be agglutinated by immune serum.

Agglutination tests have so far proved the most useful means of identifying unknown cultures, since fermentation tests may vary occasionally from strain to strain. The serum[2] is highly specific for *B. granulosis.* Fourteen known strains of the organism so far tested have been agglutinated in dilutions of 1:256 to 1:1024, while no agglutination takes place in the case of the common bacteria found in the conjunctival secretions or tissue of man or monkey (*M. albus, M. aureus, B. xerosis, B. influenzae*), or of numerous gram-negative bacteria from the same source.

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[2] A. Butenandt, *Ann. d. Chem.*, 464: 272, 1928.

[3] F. B. LaForge and L. E. Smith, *Journal Am. Chem. Soc.*, 52: 1091, 1930.

[1] Tilden, E. B., and Tyler, J. R., *J. Exper. Med.*, 1930, 52, 617.

[2] The sera have been prepared by injecting rabbits intravenously at 5- to 6-day intervals with gradually increasing doses (1 cc to 5 cc) of heavy suspensions of *B. granulosis* grown on freshly prepared nutrient agar in Blake bottles.

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